Challenging Issues in VANET Network and its Routing Algorithms-An Analysis

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***Abstract*—Vehicular Ad hoc Network (VANET), a rapidly deployed wireless network, is a subclass of mobile ad hoc networks (MANET) that uses multi-hop routing to provide network connectivity among vehicles (V2V) or vehicle to road-side equipments (V2R). VANETs have received increasing research attention in recent years because of its vast applications like safety, comfort and entertainment. Variations with time in network topology impose new challenges for routing protocols in such networks as traditional routing protocols are not suitable for VANETs. This work is an attempt to figure out the challenges in VANET comprehensively in conjunction with the recommended routing protocols by comparing the existing routing protocols with respect to existing challenges.**

***Index Terms*— Ad hoc Network, MANET, VANET, Routing Protocols.**

I. Introduction

Because of growing demand for higher capacity and higher data rates to accommodate data-intensive multimedia coupled with real-time services, wireless networks such as sensor networks, ad hoc mobile networks, cellular networks and satellite networks have experienced a explosive growth over the past few years. In ad hoc network, the mobile node, act as router exchange the information without any fixed base station. The mobile nodes steer dynamically to form their own network. Mobile Ad-hoc Network (MANET) represents a system of wireless mobile-nodes that can self-organize into uninformed and short-term network topologies without restraint and with dynamism, allowing devices to communicate without any pre-existing communication architecture [1]. MANETs have wide spread applications such as the battlefield for military purposes and other natural disaster situations. Intelligent transportation system (ITS) has been designed to improve safety and efficiency of such transportation systems along with to enable new mobile services [2]. The inter-vehicle communication consists of both vehicle-to-vehicle (V2V) and vehicle-to-roadside communication (V2R) as shown in figure 1 is known as VANET communication. In VANET, each vehicle takes the role of the sender, receiver, and routers to transmit information for automotive or transportation agency network. This information is used by the vehicles to ensure a safe and free-flow of traffic. For communication taking place between vehicles and roadside unit (RSUs), vehicles must be equipped with any radio interface which allows short-range wireless ad hoc network to provide the required information [3].

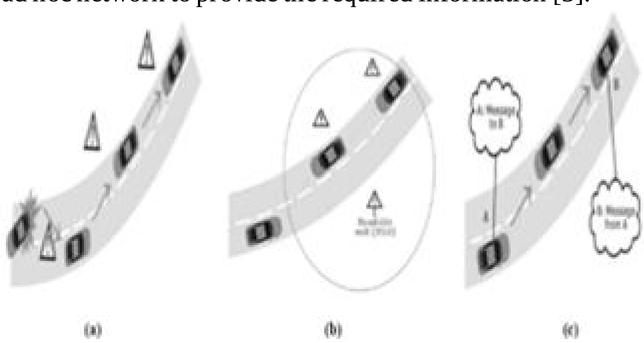

Fig. 1. Different Scenarios of VANET network (a) V2V Transmission, (b) V2R Transmission, and (c) Routing-based V2V Transmission

Vehicle to roadside communication (V2R) uses 63 GHz band, which provides a high bandwidth link between vehicle and roadside beacons, providing higher data rate to be maintained in heavy traffic beacon in every kilometer or less. V2R vehicular networks provide on-demand or real-time video and high-speed internet access. In V2R, multi-hop routing is used, where an individual message is distributed in multi-hop fashion until the message is not reached to its destination vehicle. Generally, multi-hop multicasting or broadcasting is used VANETs to transmit information within a few hops. Vehicles launch broadcasting messages periodically at regular intervals in native broadcasting. After receiving the message, the vehicle ignores the message if it comes from the vehicle behind it. If the message proceeds from the vehicle in front, receiving vehicle further broadcast its own message to the vehicles behind it. Native broadcasting method generated the large number of broadcast messages, resulting in large bandwidth consumption, therefore increase the collision between messages, which further decreases the delivery rate and increases delivery time [4]. To avoid this, an inherent acknowledgment by generation of messages and transfer strategy intelligent broadcast with implicit recognition has been introduced. This helps in improving the system performance by reducing the number of messages which are introduced into the squad for these vehicles during a disastrous event [5].

II. Challenging Issues in VANET Network

Due to self-organizing and adaptive nature of VANETs, a numerous challenges emerge to degrade its performance. In

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VANETs, the routers are free to stir and organize themselves randomly. This leads to regular route changes, network partitions, and possibly packet losses due to hasty and unpredictable variations in network topology. Moreover, each participating node may be equipped with different radio devices having unreliable transmission and receiving capabilities, and possibly operate on a different frequency bands. As a result, the probability of asymmetric links increases [6-8].

Hidden terminal problem is another challenging issue in VANETs as such networks works without RTS/ CTS exchange. It is not practical to get confirmation from all nodes that they have received a broadcast message. Without the ACK message, sender does not broadcast way to determine the successful reception of successful transmission by its neighbors. So, in VANET, different approaches like flooding, probabilistic broadcasting, cluster-based broadcasting, and location-based broadcasting can be used to message broadcast to every node. Each vehicle rebroadcasts the message in flooding/ blind flooding, whenever it receives messages for the first time. However, a large number of such redundant messages leading to contention and unnecessary collisions cause the "broadcast storm problem". When each node rebroadcast a message, it is to be expected that neighboring nodes have already received the transmission, which leads to flooding algorithm to create a large number of redundant messages. So, all nodes struggle to relay messages about the same time and hence, there will be a significant amount of nodes competing for access to the wireless channel [9].

QoS routing strategies are aimed at ensuring reliable routes between nodes and try to reduce the time required to restore the broken link. QoS of a route can be seriously affected by a factor such as node positioning, node velocity, the distance between nodes and delays between the links. QoS is achieved by resource allocation efficiently, but this cannot be achieved in VANET, as such network's topology changes swiftly with time. As most of the real time applications such as video conferencing and VoIP require faster response, any few milliseconds delay for these applications will make message meaningless and may be devastating [10-11]. LDM-STREAM ensures QoS by identifying redundant nodes of the source to prevent the transmission of duplicate information and thus improves the delay of messages [4]. In view of the road- and vehicular-security, each message must be certified its origin and control-level permissions. This is done by assigning each message of a source-vehicle with its private key, together with the certificate. When another vehicle receives this message, it checks key used to sign the message and once that is done, it checks the message. To eliminate the vulnerability of confidentiality, a set of unsigned keys are changed frequently depending on the speed of movement. It means these assigned keys are used just for one time and expire after usage. ELP (Electronic license plate) is another alternative to be installed at the factory for each new car. It will provide the vehicle an identification number to identify the vehicle at any place, with RFID technology of the ELP [12]. The connections between nodes can be a very short-lived, and possibly will not happen again, and probable makes a connection with other vehicles, because each vehicle has high mobility and may go in the opposite direction [13-14]. The conditions become more severe with the increase of the traffic volume without changing the system components and protocols results in degradation of performance of VANET. So, a secure mobility with network scalability is a hard challenge in such networks.

Some of the other problems associated with VANETs are the fluctuations in received signal strength, high channel-load, and high mobility using different types of messages such as broadcast messages, event driven messages, and the problem associated with bidirectional links.More realistic models need to be developed to model communication protocols properly [15]. Also, fair sharing of available bandwidth in VANETs becomes a real challenge in present time due to a huge amount of intranet and internet applications. There are two types of safety messages used in VANETs. Firstly, periodic messages alert other vehicles in the area of the vehicles state and secondly, emergency warnings used to trigger by a non-safe driving condition. When the number of nodes sending periodic broadcasts is too large due to high traffic volume, the emergency warning messages take a greater amount of time to be received as bandwidth availability is less in wireless networks [16].

III. Routing Algorithms in VANET Network

Generally, sense and uphold the optimal route to send data packets via intermediate nodes is the main motive of a routing algorithm. In VANETs, due to the dynamic nature of mobile nodes, searching and saving routes is a complex task. In view of the fact that VANETs used special routing protocols originally implemented for MANETs. The addresses and topology-based routing protocols require a unique address for each participating node. This means that a mechanism is desired that can be used to assign unique addresses for vehicles, but these protocols do not guarantee to avoid duplicate allocation addresses in the network. Thus, the current algorithms used in MANETs are not appropriate in case of VANETs. Specific VANETs issues such as network topology, mobility model, traffic volume, rapid changes, and the width of the road make use of these conventional routing protocols insufficiently unequivocal.

Most of the routing protocols follow two different approaches to design the inherent ad-hoc networks that are table driven routing and source initiated on-demand routing approaches. The table-driven routing, also known as proactive routing protocols maintain the routing information, connecting each node to all other nodes participating in the network. These protocols allow each node to have a clear and consistent view network topology by distributing the periodic updates [17-18]. The benefit of proactive routing protocol is that there is no route discovery since the destination route kept in the background, but the lack of this protocol is that it provides a low latency in real time, which

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leads to maintaining unused data paths,results in reduction in available bandwidth. Some of the existing table driven protocols are DSDV, GSR, WRP and ZRP. On Demand or Reactive protocols such as DSR, AODV and TORA invokes the route discovery process at the time of a transmission process. The route remains convincing until the route is no longer desirable. Such algorithms are best suited for MANETs but not for VANETs.

Various position-based and geographical protocols are also demonstrated for VANET networks. The position-based routing requires information about the physical location of all the nodes within a VANET. One of the best known position based routing is GPSR (Greedy perimeter stateless routing), which operates on the principle of a combination of greedy forwarding and face routing. On performance comparison with topology-based routing in urban- and highway- traffic scenarios, position-based routing has been identified as advanced routing paradigm for VANETs and works best in open space scenario with uniformly distributed nodes [19-20]. In city conditions, GPSR suffers from many problems such as non-availability of direct links between the nodes due to obstacles such as buildings and trees. This results in routing performance degradation due to longer paths, and leading to higher delay.

To overcome these problems, greedy routing is proposed such as GPCR (Greedy perimeter coordinator routing) in which greedy algorithm simply follow in the nodes. The routing decision is taken in case of crossing streets and shows a higher delivery rate in comparison with GPSR with a large number of hops and a slight increase in latency. However, these models are not able to work effectively in VANETs with high-rise buildings and the uneven concentration of roads. In VANET, another position based routing technique i.e. STAR, which uses a map with street names, as well as decide on the route at junctions. It uses statistically or dynamically rated maps to evaluate the traffic circumstances and make out ways to the junctions with a high connectivity for packet delivery. STAR also uses a new, more suitable local recovery strategy package to provide better performance compared to the GSR and GPCR in city networks [21].

In Geographical routing protocols, each node can determine its location as well as destination location. With this information, a message can be sent to the destination without knowing the network topology or the discovery of the route. There are different routing approaches, for example, a single path, multipath, and floods on the basis of their algorithms. In single-channel strategy, greedy forwarding is trying to bring the message closer to its destination at each step, using only local information. Thus, each node sends a message to a neighbor that is most appropriate from a local point of view. The most suitable neighbor may be someone who minimizes the distance to the destination at each step. Greedy forwarding can lead to a dead end, where there are no neighbors closer to the destination. Then, face routing helps to recover from this situation and find a path to another node where greedy forwarding can be resumed [22].

Conclusions

In this paper, it has been observed that in implementation of VANETs, the designers have to take care of a number challenging issues like fast route variations, hasty and unpredictable variations in network topology, hidden terminals, broadcast storm problem, confidentiality, a secure mobility, network scalability, and high mobility. To combat with these issues, researchers have recommended a numbers of routing algorithms depending upon different scenarios. It has been concluded that a position based- and geographical- protocols are best suited protocols over table driven- and reactive- routing algorithms. GPCR, a position based routing showed a higher delivery rate in comparison with GPSR with a large average number of hops. In case of uneven concentration of vehicles on the roads, another position based routing technique i.e. STAR routing is preferred, to provide better performance compared to GSR and GPCR. Further, Geographical routing is recommended as it provides transmission independent of network topology and is also capable of handling dead end situation.

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